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Doctoral Dissertation Abstract

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Course 地域共生工学

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1. Dissertation Title (If in English, add the Japanese translation.)

Research on Artificial Fish Swarm Algorithm

(人工的魚群アルゴリズムに関する研究)

2. Abstract (Roughly 2,000 Japanese characters or 800 English words)

Swarm intelligence provides great insights of helping humans solve complex problems. Drawing on the great insights, researchers put forward many effective swarm intelligence-based optimization algorithms, such as ant colony optimization (ACO), particle swarm optimization (PSO), artificial fish swarm algorithm (AFSA), etc. Thereinto, AFSA is relatively new and needs to be well investigated. Although AFSA has been successfully applied to solve many complex optimization problems, it has not yet attracted wide attention as ACO or PSO. An exhaustive investigation on AFSA's influence in Chapter 1 shows that AFSA indeed need wider attention. In Chapter 1, the reasons why AFSA does not attract as much attention as the other swarm intelligence-based optimization algorithms are detailedly analyzed. After that, a comprehensive review of AFSA-related research works follows. Moreover, the objectives and contributions of this thesis are respectively briefed. At the end of this chapter, the outline of this thesis is given.

In chapter 2, the introduction to AFSA's principle is briefed at the beginning. The explanation of various behaviors performed by AF individuals and the behavioral strategy is detailed after that. The detailed descriptions of two representative and commonly accepted versions of AFSA, i.e. the AFSA for global optimization of continuous function and the AFSA for combinatorial optimization problems, are respectively given.

Chapter 3 presents an AFSA to solve the multicast routing problem, which is abstracted as a Steiner tree problem in graphs. AFSA adopts a 0-1 encoding scheme to represent the artificial fish (AF), which are the subgraphs in the original graph. For evaluating each AF individual, we decode the subgraph into a Steiner tree. Based on the adopted representation of the AF, we design three AF behaviors: randomly moving, preying, and following. These behaviors are organized by a strategy that guides AF individuals to perform certain behaviors according to certain conditions and circumstances. In order to investigate the performance of our algorithm, we implement exhaustive simulation experiments. The results from the experiments indicate that the proposed algorithm outperforms other intelligence algorithms and can obtain the least-cost multicast routing tree in most cases.

Chapter 4 presents an artificial fish swarm algorithm (AFSA) for solving symbolic regression problems. This study is the first attempt of applying AFSA in symbolic regression. Gene expression scheme of genetic expression programming (GEP) is adopted to represent AF individuals. For evaluating AF individuals, a penalty-based fitness function, in which the node number of the parse tree is considered to be a constraint, was designed in order to obtain a solution expression that not only fits

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the given data well but is also compact. A number of important conceptions are defined, including distance, partners, congestion degree, and feature code. Based on the above concepts, the implementations of four behaviors, including randomly moving, preying, following, and avoiding, are described in detail. The exhaustive simulation results demonstrate that the proposed AFSA can not only obtain a high-quality solution expression but also provides remarkable robustness and quick convergence.

A new AFSA for solving the multiple knapsack problem is introduced in Chapter 5. In this AFSA, AF individuals are only allowed to search the region near constraint boundaries of the problem to be solved. For this purpose, several behaviors to be performed by AF individuals, including escaping behavior, randomly moving behavior, preying behavior and following behavior, were specially designed. Exhaustive experiments were implemented in order to investigate the proposed AFSA's performance. The results demonstrated the proposed AFSA in this chapter has the ability of finding high-quality solutions with very fast speed, as compared with some other versions of AFSA based on different constraint-handling methods. This study also has wider implications for solving other constrained problems.

Chapter 6 presents a symbiosis-based AFSA, which employs two AF sub-populations to collaboratively search the solution space of the problem to be solved. The symbiosis-based computational framework makes AF individuals be able to adjust their *Visual*-limit and *Step*-limit. Beyond that, in order to make AF individuals swim toward the weighted centre of its partners when performing gathering behavior, a method of determining the weighted centre is proposed. In addition, a newly designed behavioral strategy for AF is also presented in view of the symbiosis-based framework. Experiments were conducted on several test functions. The results demonstrate good performance of the symbiosis-based AFSA.

Chapter 7 discusses the necessary modifications to AFSA when using it in problem-solving, including the modifications to AF representation scheme, that to AF behaviors, that to behavioral strategy, and that to some conceptions in AFSA. The open and flexible optimization framework of AFSA is also discussed in detail. Since AFSA has a number of parameters to tune, this chapter also discusses how to tune the parameters. After that, the applicability of AFSA is analyzed.

Research is an iterative process, just like that of AF individuals searching in the solution space. Researchers keep exploring new frontiers of knowledge not only based on their own successes, but also the successes learnt from the other researchers. The presented research in this thesis is no exception. In addition, it is hoped that the presented research works in this thesis may help the other researchers explore new aspects and attract more researchers' attention to AFSA such that they devote themselves into the further research of AFSA.